

1 circuit according to a preferred embodiment of the present invention.

2 FIG. 2 is a schematic circuit diagram of the DC bias equivalent circuit
3 according to a preferred embodiment of the present invention.

4 **[Detail Description of the Invention]**

5 **[Objects of the Invention]**

6 **[Field of the Invention and Background of the Invention]**

7 The present invention relates to a subscriber matching circuit for an
8 electronic exchange. In particular, the present invention relates to a subscriber
9 matching circuit for an electronic exchange which matches transmitted/received
10 data so as to permit call communications between the exchange and subscribers.

11 Generally, in an electronic exchanger, a subscriber matching circuit for
12 matching with subscribers requires the functions of line current supply, supervision
13 of a subscriber's state, call signal supply (ring signal supply) and detection, 2-line/4-
14 line conversion, etc. The line current supply function serves to supply current for
15 operating a subscriber's telephone and to supervise the on-hook/off-hook state of the
16 telephone by detecting the variation of the supplied current. The line current supply
17 function, which is performed with a function of limiting a maximum line current,
18 serves to prevent unnecessary power consumption due to an oversupply of the line
19 current to a short-distance subscriber. The 2-line/4-line conversion function serves
20 to convert a 4-line signal transmitted from the telephone exchange or through
21 transmission lines into a 2-line signal, while converting the 2-line signal transmitted
22 from the subscriber's telephone into the 4-line signal.

1 Such an analog type subscriber matching circuit may employ a conventional
2 transformer. However, it cannot be adapted to the present-day trend of the high-
3 density integration and miniaturization due to its large size and magnetic saturation
4 caused by the line current. In order to adapt the trend of the high-density integration
5 and miniaturization, the subscriber matching circuit has been integrated into an
6 SLIC integrated circuit (IC). A subscriber matching circuit using the SLIC IC is
7 disclosed in Korean Patent Application No. 1994-40809 filed by the applicant of the
8 present invention. According to the subscriber matching circuit disclosed in Korean
9 Patent Application No. 1994-40809, however, all circuit elements are integrated
10 onto one chip, and thus it is relatively vulnerable to external impacts such as
11 lightning strikes in comparison to the circuit employing the transformer. As a result,
12 it requires a protection device as well as many peripheral parts thereof for
13 performing the subscriber matching function, thereby increasing the possibility of
14 experiencing difficulties in operation.

15 **[Technical objects for supporting the present invention]**

16 It is an object of the present invention to solve the problems involved in the
17 related art, and to provide a hybrid subscriber matching circuit for an electronic
18 telephone exchanger which can simplify the peripheral parts thereof and strongly
19 resist an external impact or shock.

20 **[Structure and Operation of the invention]**

21 The embodiment of the present invention is described in detail hereinafter

1 with the accompanying drawings.

2 FIG. 1 shows an embodiment of the hybrid subscriber matching circuit
3 according to the principle of the present invention.

4 The hybrid subscriber matching circuit for a full electronic exchanger
5 according to the principle of the present invention includes transistors Q1 and Q2
6 supplying a line current to a subscriber through a tip terminal and a ring terminal,
7 transistors Q3 and Q4 having a Darlington structure connected to the transistors Q1
8 and Q2 respectively and limiting a maximum current, current supervising resistors
9 R1 and R2 connected to emitters of the transistors Q1 and Q2 respectively and
10 performing a current feedback operation to limit the maximum current and detecting
11 a voltage form of a line current flowing through telephone lines, a resistors R3
12 connected between a collector of the transistor Q1 and a collector of the transistor
13 Q3 and preventing the transistors Q1 from being saturated, a resistor R4 connected
14 between a collector of the transistor Q2 and a collector of the transistor Q4 and
15 preventing the transistors Q2 from being saturated, three bias resistors R5, R6 and
16 R7 determining a threshold value of the maximum current and allowing the
17 transistors Q1 and Q2 to be in an active state, diodes D1 and D2 preventing the
18 transistors from being overheated due to a variation of the threshold value of the
19 maximum current and the heat generated by the line current (I_L), bypass capacitors
20 C1, C2, C3 and C4 preventing a bad influence on call communications due to the
21 generation or induction of noise introduced in the DC line current supply, capacitors
22 C5 and C6 superimposing a received audio signal (i.e., an AC signal) on the DC line
23 current, composite impedances ZL1 and ZL2 matching line characteristic

1 impedance, amplifiers AMP1 and AMP2 receiving and amplifying the audio signal,
2 protection elements CR1 and CR2 protecting the amplifiers AMP1 and AMP2 from
3 being an over current state through lines, a resistor R11 converting the line current
4 flowing through the resistor R1 into an input current for detecting an off-hook state,
5 an operational amplifier AMP3 inversion-amplifying a signal inputted through the
6 resistor R11, a resistor R13 determining an amplification factor of the signal
7 inputted through the resistor R11, a transistor Q6 converting a level of the signal
8 inversion-amplified by the operational amplifier AMP3, a resistor R10 detecting a
9 ring trip voltage if a telephone handset is hooked off during supply of a call signal,
10 a resistor R12 converting the voltage detected by the resistor R10 into a ring trip
11 current, a capacitor C7 allowing the operational amplifier AMP3 to serve as a low-
12 pass filter so that an AC amplification factor is greatly lowered to remove AC ripple
13 components included in the ring trip current, and a field effect transistor FET1
14 allowing the operational amplifier AMP3 to serve as a low-pass filter in a ring
15 current supply state.

16 FIG. 2 shows the DC bias equivalent circuit according to the principle of the
17 present invention.

18 The operation of the embodiment of the present invention is now explained
19 in detail with reference to FIGS. 1 and 2.

20 The transistors Q1 and Q2 are to supply the current, and the transistors Q3
21 and Q4 are to limit the maximum current. The equivalent circuit of FIG. 2 performs
22 the line current supplying function. Since the circuit for supplying the line current

can be used for both a tip terminal and a ring terminal which have the symmetrical arrangement in this embodiment, FIG.2 illustrates only the equivalent circuit for the line current supply on the tip terminal side. Referring to FIG. 2, the line current (I_L) becomes $I_{b1} \cdot h_{FE}$.

The resistors R5 and R6 form a bias current I_{b2} of the transistor Q2, which is given by the following mathematical expression 1.

[Expression 1]

$$I_{b2} = \frac{(V1 - V_{BE1} - V_{BE3})}{(Rb + R1)}$$

$$V1 = \left(\frac{V_{bat}}{2} - 2V_D \right) \times \frac{R5}{\left(\frac{R6}{2} + R5 \right)}$$

$$Rb = R5 // \frac{R6}{2}$$

The line current (I_L) increases if the resistor R_L of the speech line decreases, and as the line current (I_L) increases, the terminal voltage V_{R1} of the resistor R1 also increases. If the voltage V_{RL} decreases due to the current feedback which decreases the base current I_{b1} of the transistor Q1 and the decrease of the resistance of the resistor R_L of the speech line, the collector voltage V_{CE1} of the transistor Q1 increases. The increase of the collector voltage V_{CE1} of the transistor Q1 causes the

1 increase of the current I_{b1} through the resistor R3. The bias stability is improved by
 2 the voltage feedback which decreases the collector voltage V_{CE1} of the transistor Q1.
 3 Another important role of the resistor R3 is to prevent the saturation of the transistor
 4 Q1. Specifically, if the resistor R_L of the speech line increases, the line current (I_L)
 5 and the collector voltage V_{CE1} of the transistor Q1 decrease. The decrease of the line
 6 current (I_L) causes the decrease of the amount of the current feedback through the
 7 resistor R1. The continuous increase of the resistor R_L of the speech line causes the
 8 continuous decrease of the line current (I_L) and results in that the collector voltage
 9 V_{CE1} of the transistor Q1 extremely decreases to reach the saturation region of the
 10 transistor Q1. At this time, the base current I_{b1} of the transistor Q1 which is
 11 supplied through the resistor R3 decreases due to the decrease of the collector
 12 voltage V_C of the transistor Q1, and thus the saturation of the transistor Q1 is
 13 prevented. Actually, this prevents the distortion of the AC characteristic in a long
 14 loop in which the line resistor R_L increases.

15 Also, the maximum current limitation is effected by the current feedback
 16 through the resistor R1. The increase of the line current I_L causes the increase of the
 17 terminal voltage V_{R1} , and the current limitation is performed when the line current
 18 (I_L) reaches a value corresponding to the state that the voltage of $V_{R1} + V_{BE1} + V_{BE2}$
 19 becomes equal to the voltage of V_1 . However, if the current limitation is actually
 20 generated due to the current increase, V_{CE} of the transistor Q1 increases, and this
 21 causes the power consumption as much as $I_{L1} * V_{CE}$ to be generated in the transistor
 22 Q1, resulting in heat generation in the transistor Q1. Since V_{BE} is in negative

1 proportion to the temperature (that is, $-2.4\text{mV}/^{\circ}\text{C}$), V_{BE} decreases as the temperature
2 increases, and this causes the current limitation value increases. An undesirable
3 repetition of such operations results in an error in the limited current. As a result,
4 the maximum current, much higher than the limited current actually required, flows.
5 In order to prevent this overheating phenomenon, the diode D1 which has a forward
6 voltage-temperature characteristic is connected between the base of the transistor
7 Q2 and the ground. In this case, since the forward voltage of the diode decreases to
8 the same level as V_{BE} of the transistors Q1 and Q2 due to the heat generated in the
9 transistor Q1, the variation of the limited current to the temperature is offset, and
10 thus the limited current can be more stably determined. Though the transistors Q1
11 and Q2 are connected in a Darlington structure, the base current I_{b1} of the transistor
12 Q1 is actually limited by the resistor R3. The purpose of this construction is not to
13 improve the voltage gain by supplying an input signal to the base of the transistor
14 Q2, but to improve the gain of the current feedback performed by the resistor R1.
15 In other words, when the resistor R_{L} of the line varies within the range of the limited
16 current, the limited current is kept constant with respect to the variation of R_{L} of the
17 line by the transistors Q1 and Q2.

18 Meanwhile, the line current supervising function serves to convert the line
19 current into a logic signal by driving the transistor Q6 with an inversion-amplified
20 output of the voltage variation of the resistor R1. The line current supervising circuit
21 of FIG. 1 also performs the ring trip function simultaneously. Specifically, if the line
22 current (I_{L}) increases, the voltage drop is generated by the resistor R1, and this
23 voltage drop is inversion-amplified with the gain determined by the resistors R11

1 and R13 to drive the transistor Q6. If the transistor Q6 is driven, a logic "0" (low)
2 signal is outputted from the collector of the transistor Q6 to a detection terminal
3 DET. At this time, the line current (I_L) corresponding to the condition that the
4 detection terminal DET is in the logic "0" state is determined by the resistors R11
5 and R12. The line current supervising circuit also supervises whether the handset
6 is hooked off if the ring current is supplied during the supervision of the line current
7 (I_L). Specifically, a ring relay K1 is switched to the resistor R10, and the ring current
8 supplied from the ring terminal is applied to the tip terminal via the line resistor R_L
9 and the terminal telephone. In the off-hook state, the line resistor R_L including the
10 DC resistance of the terminal telephone decreases abruptly, and this causes the
11 voltage drop formed between the terminals of the resistor R10 to increase. This
12 dropped voltage is applied to the inverting terminal of the operational amplifier
13 AMP3 through the resistor R12 to be inversion-amplified. Accordingly, the output
14 signal of the operational amplifier AMP3 becomes high, and is applied to the base
15 of the transistor Q6 to turn on the transistor Q6, so that a low level signal is
16 outputted to the detection terminal DET to indicate the off-hook state of the
17 telephone. When the voltage drop of the resistor R10 increases, the signal inputted
18 to the inverting terminal of the operational amplifier AMP3 for inversion-
19 amplifying the terminal voltage of the resistor R10 becomes the DC signal
20 superimposed with the AC ring signal, and thus it is required to greatly reduce the
21 gain of the inversion amplifier AMP with respect to the AC signal in order to detect
22 the DC signal only. The reduction of the AC gain in the operational amplifier AMP3
23 invites the reduction of the AC gain by the capacitor C7 connected in parallel to the

1 resistor R13, and thus the DC signal with its ripple component greatly suppressed
2 is outputted from the operational amplifier AMP3, enabling the ring trip operation
3 to be performed accurately. The field effect transistor FET1 is turned on only when
4 the ring relay K1 operates, and thus has no effect on the line current supervising
5 function in a normal state. At this time, since the capacitance of the capacitor C7
6 cannot be selected as an infinite value, the resistors R11, R12 and R13 should have
7 a large resistance value in the range of several hundred kilo-ohms ($K\Omega$) in order for
8 the capacitor C7 having a small capacitance value to act as a low-pass filter.

9 **[effects of the invention]**

10 As described above, the subscriber matching circuit according to the present
11 invention is designed to use general parts while it performs the same function as the
12 conventional analog subscriber matching circuit using a transformer or SLIC, and
13 thus the manufacturing cost thereof can be greatly reduced. Further, the subscriber
14 matching circuit according to the present invention has an on-hook transmission
15 function, and thus can be applied to additional services such as remote charging,
16 transmission of a calling subscriber's number, etc.